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Age differences in technology adoption decisions: implications for a changing work force — Source link

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AGE DIFFERENCES IN TECHNOLOGY ADOPTION DECISIONS: IMPLICATIONS FOR A CHANGING WORK FORCE

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This research investigated age differences in individual adoption and sustained usage of technology in the workplace using the theory of planned behavior. User reactions and technology usage behavior were studied over a 5-month period among 118 workers being introduced to a new software system. At 2 points of measurement, compared to older workers, younger workers' technology usage decisions were more strongly influenced by attitude toward using the technology. In contrast, older workers were more strongly influenced by subjective norm and perceived behavioral control, although the effect of subjective norm diminished over time. These findings were robust, even after controlling for key confounding variables identified in prior organizational behavior research (i.e., income, occupation, and education levels). Theoretical and practical implications for understanding the effects of aging on technology adoption and usage in the workplace are discussed.

Throughout the past decade, changing demographic patterns and cultural influences have led to an increasingly older workforce (Sharit & Czaja, 1994; Warr, 1990). Although age differences have been of significant interest to psychology researchers and practitioners for over 6 decades (e.g., Girard, 1993; McCarty & Shrum, 1993; Minton & Schneider, 1980; Rhodes, 1983), there has been relatively little research on the influence of age on technology adoption decisions in an organizational context.

As a result of today's fast-paced and complex work environment, organizations have often elected to deploy sophisticated information technology to help employees manage this complexity (Gilroy & Desai, 1986). Yet there is some evidence that age has an important influence on technology usage in the workplace. For example, evidence

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suggests that age differences in information processing have an impact on older workers' performance of computer-based tasks (e.g., data entry, file maintenance, and inventory management) (Czaja & Sharit, 1993; Sharit & Czaja, 1994). Thus, it appears that gaining a better theoretical understanding of age differences is important—particularly as they relate to user acceptance and usage of new information technologies in the workplace. Taking a longitudinal approach with data gathered from 118 individuals in a field setting, this research attempts to achieve two primary objectives:

1. Understand age differences in the relative influence of the original theory of planned behavior constructs (attitude toward behavior, subjective norm, and perceived behavioral control) on usage of a new technology.
2. Understand age differences over the long term as it relates to sustained usage of technology with increasing experience with the new technology.

Background

Age Differences

A long line of research exists that looks at socio-cognitive changes among individuals based on chronological age. For many years, researchers argued that aging was accompanied by a decline in intellectual ability or intelligence (e.g., Wechsler, 1958). Today, there is less support for a unidimensional view of intelligence—rather, more contemporary views have focused on specific types of abilities having different age functions—for example, verbal scores do not change with age while performance scores decline with age (e.g., Botwinick, 1967, 1977). Likewise, crystallized intelligence does not change with age while fluid intelligence can change or remain constant (e.g., Baltes & Lindenberger, 1997; Horn, 1977; Schaie & Willis, 1986).

Taken together, these results present a life cycle orientation whereby job needs and preferences change with age. In fact, many have promoted theories that apply life cycle approaches to job-related attitudes and behavior as important contributions to psychological theories of aging (e.g., Rhodes, 1983). Therefore, the proposed model addresses this need for theoretically based research on age differences in the increasingly important area of technology acceptance and usage in the workplace.

Theory of Planned Behavior

The primary theoretical framework for this research is Ajzen's (1985, 1991) theory of planned behavior (TPB). TPB has been widely applied across a range of disciplines including marketing/consumer behavior (Berger, 1993), leisure behavior (Ajzen & Driver, 1992) and medicine (Randall & Gibson, 1991), among others. TPB has also been applied by organizational psychologists to study adoption of new technologies (e.g., Mathieson, 1991; Taylor & Todd, 1995a). TPB defines relationships between attitudes, norms, and control as determinants of intention and behavior (Figure 1). Although intention was included in the original conceptualization of TPB, the availability of objective measures of behavior in the current research allows us to omit intention from the model and study the effects directly on behavior. The key determinants in the theoretical model are defined as follows:

1. *Attitude toward behavior* (A) "refers to the degree to which a person has a favorable or unfavorable evaluation or appraisal of the behavior in question" (Ajzen, 1991, p. 188). In a technology adoption context, the key behavior of interest is use of the system; therefore, attitude toward behavior is a potential user's affective evaluation of the costs and benefits of using the new technology.
2. *Subjective norm* (SN) "refers to the perceived social pressure to perform or not to perform the behavior" (Ajzen, 1991, p. 188). In the context of technology usage, subjective norm has manifested itself as peer influence and superior influence (Mathieson, 1991; Taylor & Todd, 1995a).
3. *Perceived behavioral control* (PBC) is defined as "people's perception of the ease or difficulty of performing the behavior of interest" (Ajzen, 1991, p. 183). Consistent with this basic definition, prior research studying technology adoption and usage behavior has related this construct primarily to constraints to technology usage (Taylor & Todd, 1995a), particularly the ease or difficulty of using the new technology.

Hypothesis Development

In studying the acceptance and use of a new technology, it is important to examine such phenomena over time in order to understand how increasing user experience with the specific system software influences usage patterns (e.g., Davis, Bagozzi, & Warshaw, 1989). Theoretically, in the earliest stages of technology introduction, users are making an "acceptance" decision. However, initial acceptance decisions have been shown to be systematically different from long-term "usage" decisions

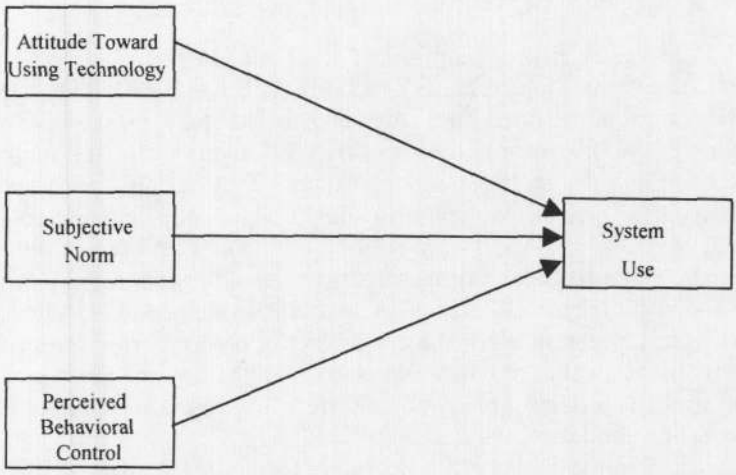

Figure 1: **Theory of Planned Behavior**

(see Davis et al., 1989; Venkatesh & Davis, in press). Therefore, in order to gain a more thorough understanding of age differences, this research studies the role of age in both initial (i.e., short-term) and continued long-term usage behavior decisions.

A large body of research on aging differences exists in the psychology literature (see Minton & Schneider, 1980; Rhodes, 1983 for reviews), focusing particularly on understanding mean differences in abilities, traits, or performance outcomes (e.g., Sharit, & Czaja, 1994). Little, if any, research has aimed at understanding age differences in the salience of different attributes—that is, the relative importance of potential determinants—in decision-making processes related to technology adoption. Figure 2 presents the specific research model proposed and tested in this research.

Effect of Age on Usage

The proposed model builds on TPB outlining the role of age as a key factor influencing usage. In order to establish the relationship between age and usage within the context of TPB and the extensions proposed in this paper, the following four conditions have to hold true:

1. age has a direct effect on usage,
2. age has an effect on A, SN, and PBC,
3. age has a moderating influence on the A–Usage, SN–Usage, and PBC–Usage relationships, and

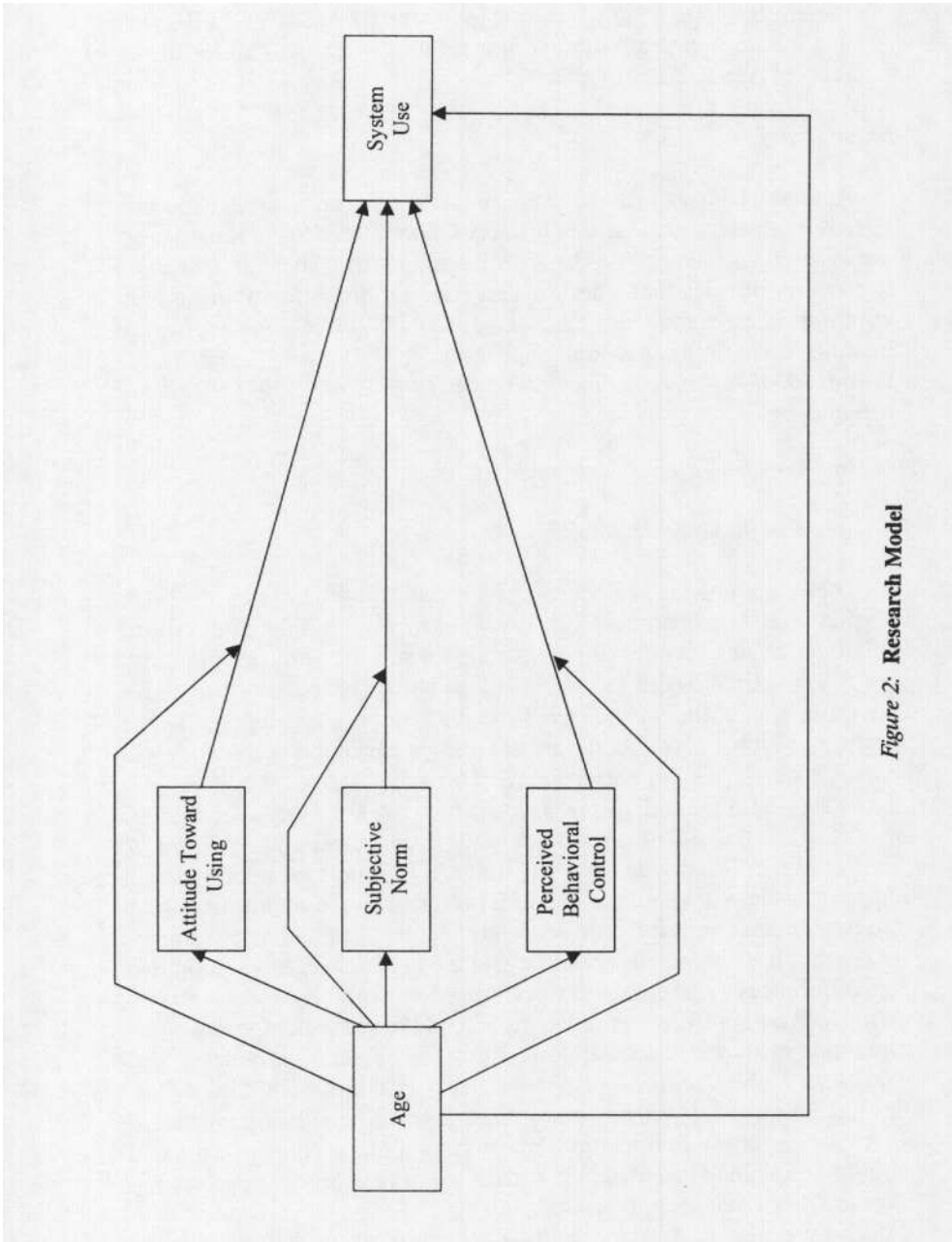

Figure 2: **Research Model**

4. the effect of age on usage is fully mediated by A, SN, and PBC (i.e., age has no significant direct effect on usage over and above the effects of A, SN, and PBC).

Short-Term Effects

Research has shown that as basic physiological processes decline with age, older workers are less able to process complex information processing tasks (e.g., Birren, Woods, & Williams, 1980). There is also some support for the idea that older workers have a more difficult time adapting to changes in the work environment and will likely take refuge in methods that are familiar to them (Dalton & Thomas, 1971; Forteza & Prieto, 1990; Myers & Conner, 1992; Sharit & Czaja, 1994). Thus, we hypothesize:

Hypothesis 1: Age is negatively related to short-term usage.

Attitude Toward Using Technology

There is significant evidence (e.g., Davis, 1989; Davis et al., 1989; Mathieson, 1991; Taylor & Todd, 1995a) to suggest that the most critical belief underlying an individual's attitude toward the behavior of adopting a new technology in the workplace is her or his perceptions about the usefulness of the technology. Perceived usefulness is defined as the extent to which a person believes that using a particular technology will enhance her or his job performance (Davis, 1989), and empirical evidence suggests that in the workplace attitude toward using a technology is, in fact, tied closely to instrumentality (Davis et al., 1989; Taylor & Todd, 1995a). Thus, in determining usage, it is important to understand differences between younger and older workers in the importance each group attaches to extrinsic factors related to usage of a new technology.

Within the organizational setting, many researchers have examined age differences with respect to work attitudes, work behaviors, and values, needs and preferences (Rhodes, 1983). For example, there is overwhelming evidence which supports a positive correlation between age and overall job satisfaction (e.g., Near, Rice, & Hunt, 1978; Siassi, Crocetti, & Spiro, 1975; Weaver, 1980). Gibson and Klein (1970) concluded that the age-satisfaction relationship was a part of the aging process and could be explained by changing needs, a mellowing process, and changing cognitive structures associated with age.

There is also evidence to suggest that younger workers tend to be more focused on job-related outcomes, task accomplishment, and extrinsic rewards (e.g., Andrisani, Appelbaum, Koppel, & Miljus, 1978;

Gould, 1979; Hall & Mansfield, 1975; Rabinowitz & Hall, 1981; Porter, 1963). Thus, we expect age to have a negative direct influence on attitude toward using a new technology that is driven by an instrumental factor (i.e., usefulness perceptions). We also expect an interaction effect of age such that attitude toward using technology will be more salient to younger workers than older workers.

Subjective Norm

Given that subjective norm in the workplace technology adoption context is tied to peer influence and superior's influence (Mathieson, 1991; Taylor & Todd, 1995a), we expect the extent of age differences in the role of subjective norm to be closely linked to the extent to which younger/older workers are influenceable and respond to informational input from peers and superiors. In the organizational environment, research suggests that older workers are more concerned with pleasing others and are more likely to conform to majority opinions (e.g., Hall & Mansfield, 1975; Porter, 1963). Other studies have documented that older workers have a lower need for autonomy (inversely related to "subjective norm") than younger workers (Aldag & Brief, 1975; Cook & Wall, 1980; Evans, Kiggundu, & House, 1979; Hackman & Oldham, 1976). Rhodes' (1983) analysis also suggested that needs for affiliation and having friendly coworkers and superiors increase with age. Therefore, in the short term, we expect that age will have a positive direct influence on subjective norm. We further expect that the subjective norm-usage relationship will be moderated by age such that normative influences will be more salient for older workers.

Perceived Behavioral Control

Following from the definition of perceived behavioral control presented earlier, TPB research (e.g., Sparks, Guthrie, & Shepherd, 1997) has provided evidence indicating that perceived difficulty—especially as it is related to internal constraints (Venkatesh, in press)—is the most important factor underlying perceived behavioral control. As noted earlier, research has shown that performance on fluid intelligence tasks declines with age (Horn, 1975, 1977). Floyd and Scogin (1997) have suggested that memory capacity decreases with age, particularly secondary memory. In addition, older individuals appear to have problems with both accessing and retrieving information from memory (Arenberg & Robertson, 1977; Craik, 1977; Elias & Elias, 1977; Minton & Schneider, 1980).

Increased age has also been shown to be associated with difficulty in processing complex stimuli and allocating attention to task-relevant information (Plude & Hoyer, 1985). Welford (1980) found that age-related working memory deficits were more pronounced when the information presented was new, in an unfamiliar cognitive domain, or complex. Further complicating the use of new technologies, one of the well-known changes associated with aging is the loss of resolving power of the visual system: older people are unable to distinguish among closely occurring visual stimuli as easily as their younger counterparts (Kline & Schieber, 1982). Therefore, specific to computer-related work, researchers have suggested strategies such as using window-based user interfaces or particular types of menu structures as especially beneficial for older workers in that they decrease the user's requirement to maintain information in working memory (Sharit & Czaja, 1994).

Given these differences in cognitive processing, access to resources and assistance provided by particular user interface design features should help make technology more usable, and such issues should be particularly salient for older workers. Therefore, we expect that age will have a positive direct influence on perceived behavioral control. We also expect an interaction effect such that perceived behavioral control will be more salient in determining usage for older workers than for younger workers.

Thus, in the short term, we propose that age will have a direct influence on each of the TPB constructs and that those constructs will mediate the influence of age on usage:

Hypothesis 2a: Age is negatively related to attitude toward using technology in the short term.

Hypothesis 2b: Age is positively related to subjective norm in the short term.

Hypothesis 2c: Age is positively related to perceived behavioral control in the short term.

In addition, based on the preceding theoretical development, we suggest that age will have an important moderating influence on the relationship between each of the TPB constructs and technology usage in the short term. Specifically, we suggest that attitude toward using is most important for younger workers, and normative and control influences are more salient for older workers. Thus, we hypothesize:

Hypothesis 3a: Age moderates the relationship between attitude toward using technology and short-term usage, such that attitude toward using will be more salient for younger workers than older workers.

Hypothesis 3b: Age moderates the relationship between subjective norm and short-term usage, such that subjective norm will be more salient for older workers than younger workers.

Hypothesis 3c: Age moderates the relationship between perceived behavioral control and short-term usage, such that perceived behavioral control will be more salient for older workers than younger workers.

Mediation of Age by TPB Constructs

Although it was suggested that age has an effect on usage (Hypothesis 1), such an effect on usage is expected to be fully mediated by attitude toward using technology, subjective norm, and perceived behavioral control. Such a contention is based on a key TPB premise that TPB constructs will fully mediate the effect of external variables (such as age) on intention and behavior. Thus, we hypothesize:

Hypothesis 4: The effect of age on short-term usage will be fully mediated by attitude toward using technology, subjective norm, and perceived behavioral control.

Long-Term Effects

As in the short term, we first examine the direct effect of age on long-term usage as a basis for later understanding the potential mediating effects of the TPB constructs and/or the moderation of those constructs' relationship with technology usage by age. The basic rationale suggesting a negative relationship between age and usage in the short term also applies over the long term. Therefore,

Hypothesis 5: Age is negatively related to long-term usage.

Attitude Toward Using Technology

In a previous study of technology adoption and sustained usage (e.g., Davis et al., 1989), there is evidence to suggest that the effect of attitude toward using technology on intention/behavior remained strong even after 14 weeks of use. Related psychology research also supports the notion that attitudinal components tend to be strong determinants of intention/behavior with increasing direct experience with the target behavior (Doll & Ajzen, 1992; Fazio & Zanna, 1978a, 1978b, 1981; Regan & Fazio, 1977) for up to a year (Reinecke, Schmidt, & Ajzen, 1996). Based on an accumulation of evidence (e.g., Taylor & Todd, 1995a) it is clear that instrumental factors are not simply important *initial* determinants of behavior—they remain important over the *long term*. Therefore, we ex-

pect age differences with respect to direct influences on attitude toward using will be sustained over time. We also expect that the moderating the influence of instrumental factors that were present at the time of the initial acceptance decision will sustain over time with increasing direct experience with the specific technology.

Subjective Norm

To understand age differences in subjective norm over the long term, it is necessary to consider the role of experience and how that experience can influence the importance of others' opinions in determining usage for any one individual. In early stages of user experience (see Hypothesis 2b, Hypothesis 3b), even if an individual does not have a favorable reaction to the system, if they are motivated by one or more important referents, the individual will tend to *comply* with others' views and use the target system (see Warshaw, 1980).

However, as direct experience with the technology increases over time, individuals begin to form a better independent assessment of the benefits and costs associated with using that technology. Even in cases where their original decision was based on others' opinions, individuals begin to *internalize* the opinions of others (Oliver & Bearden, 1985; Warshaw, 1980). Therefore, over time, this results in a reduction of the direct effect of subjective norm on intention/behavior (e.g., Reinecke et al., 1996). Thus, consistent with a shifting causal mechanism (i.e., from compliance to internalization), the direct effect of subjective norm on use is expected to diminish. Specifically, although age is expected to continue to have a direct effect on subjective norm, the effect of subjective norm in determining usage will become nonsignificant for both younger and older workers over the long term.

Perceived Behavioral Control

Cognitive processing differences between older and younger workers related to processing complex stimuli (Plude & Hoyer, 1985) and distinguishing among visual cues in a complex information environment (Cerella, Poon, & Fozard, 1982; Kline & Schieber, 1982; Walsh & Prasse, 1980) are likely to continue to be important issues for older workers and will not be resolved with increasing experience with the technology. In addition, prior research (e.g., Bergeron, Rivard, & De Serre, 1990) has suggested that support staff is one of the most crucial elements in alleviating constraints to technology usage. Research from organizational psychology has suggested that older workers place greater importance upon receiving help and assistance on the job (Hall & Mansfield, 1975).

Thus, older workers may be more motivated to tap the assistance support staff as they continue using technology (i.e., with increasing levels of experience). Therefore, we expect that age will continue to have an important influence on perceived behavioral control in the long run. Furthermore, the cognitive differences based on aging as well as the availability of support staff to alleviate constraints to technology are likely to make perceived behavioral control more salient for older workers than younger workers over the long term.

Thus, over the long term, we expect age will continue to have a direct effect on attitude toward using technology, subjective norm, and perceived behavioral control, and moderating effects on the A–Usage, SN–Usage, and PBC–Usage relationships. Thus, we hypothesize:

Hypothesis 6a: Age is negatively related to attitude toward using in the long term.

Hypothesis 6b: Age is positively related to subjective norm in the long term.

Hypothesis 6c: Age is positively related to perceived behavioral control in the long term.

Hypothesis 7a: Age moderates the relationship between attitude toward using and long-term usage, such that attitude toward using will be more salient for younger workers than older workers.

Hypothesis 7b: Age does not moderate the relationship between subjective norm and long-term usage.

Hypothesis 7c: Age moderates the relationship between perceived behavioral control and long-term usage, such that perceived behavioral control will be more salient for older workers than younger workers.

Mediation of Age by TPB Constructs

Consistent with our theoretical frame for this paper, the effect of age on usage is expected to be fully mediated by attitude toward using technology, subjective norm, and perceived behavioral control. Thus, we hypothesize:

Hypothesis 8: The effect of age on long-term usage will be fully mediated by attitude toward using technology, subjective norm, and perceived behavioral control.

In sum, the current research proposes age as an important variable in understanding technology usage, both in the short-term (Hypothesis 1) and long-term (Hypothesis 4). In seeking to better understand the influence of age, we suggest that age may affect usage in two ways: first, through its effect on TPB constructs (Hypothesis 2a–c; Hypothesis 5a–c) and as a potential moderator of relationships derived from the TPB

(Hypothesis 3a–c, Hypothesis 6a–c). Finally, the effect of age on intention and behavior is expected to be fully mediated by TPB constructs (Hypothesis 4 and 8).

Research Method

Participants and Systems

The setting for the research was a medium-size financial accounting firm in a large midwestern city with approximately 300 personnel. The firm was well established in the community and had been in business for about 15 years. A total of 130 customer account representatives who were in the process of implementing a new technology participated in the study, and 118 usable responses were obtained at all points of measurement. The specific software being introduced was a new Windows95-based organization-wide system for data and information retrieval. The system was used for all internal accounting transactions and for organizational knowledge management via a virtual community of customer service representatives. Usage of the new system was voluntary because the participants could use either the new system or the existing system. The first year of implementation was considered a trial period after which an executive decision would be made on whether to continue use of the new system or revert to the existing system. None of the participants had any prior knowledge about the software technology being introduced. All participants received a 2-day training session on the system, with the first day of training focusing on concepts and features of the system and the second day including 2 hours of interactive lecture (i.e., lecture combined with hands-on use), and 4 hours of hands-on use (with consultants being available to help). In the interest of delivering the highest quality training, the participating organization conducted multiple sessions with the same training staff over a 2-week period with about 25 participants in each session. Additional centralized support staff provided help to subjects with questions or problems during the week after training. The trainers and (software) consultants did not know about the research or its objectives.

Potential Confounding Factors

There are several important demographic variables that could potentially confound observed age differences. The most important covariates are those which, upon inclusion, might (theoretically) eliminate age differences. Three potential confounds associated with age include income,

occupation, and education (e.g., Minton & Schneider, 1980). Specifically, older individuals are overrepresented in categories of higher income, higher occupational positions, and higher educational qualifications. Thus, in the current research, it was deemed important to first evaluate (and control, if necessary) the effects of income level, occupation level, and education level (see Gould & Werbel, 1983; Kite, 1996; Praeger, 1986).

Procedure and Measurement

User reactions and usage behavior were measured over a period of 5 months. Subjects participated in a 2-day training program on the system. Neither the lecturers nor the software consultants knew about the research or its objectives. User reactions to the technology were gathered at two points in time: immediately after the initial training (t_1) and after 3 months of experience (t_2). Actual usage behavior (USE) was measured over a 5-month period from the time of initial introduction of the technology. For purposes of this research, t_1 represented the measurement point to study short-term effects (i.e., initial user reactions), and t_2 represented measurements to study long-term effects (i.e., situations of significant direct experience with the technology). We expected that analyzing user perceptions and behavior at these two separate points in time would help us gain an understanding of the influence of experience in this context. To that end, using the different points of measurement as a proxy for experience with the new technology is consistent with prior research in the domain (e.g., Davis et al., 1989) and our other work in this area (Venkatesh, in press; Venkatesh & Davis, 1996, in press; Venkatesh & Morris, in press; Venkatesh, Morris, & Ackerman, in press; Venkatesh & Speier, 1999). A, SN, and PBC measured in a specific time period (e.g., t_1) were used to predict subsequent usage behavior. Figure 3 presents a summary of the design and points of measurement of this research.

Validated items were used to measure attitude toward using technology, subjective norm, and perceived behavioral control (Davis, 1989; Davis et al., 1989; Mathieson, 1991; Taylor & Todd, 1995a, 1995b). Actual usage behavior (USE), operationalized as the frequency of use (number of user queries for information), was gathered from system logs. Consistent with prior research in sociology and organization behavior, demographic variables of interest: age, income, organizational position, and education were measured. The Appendix presents a list of the items used in this research.

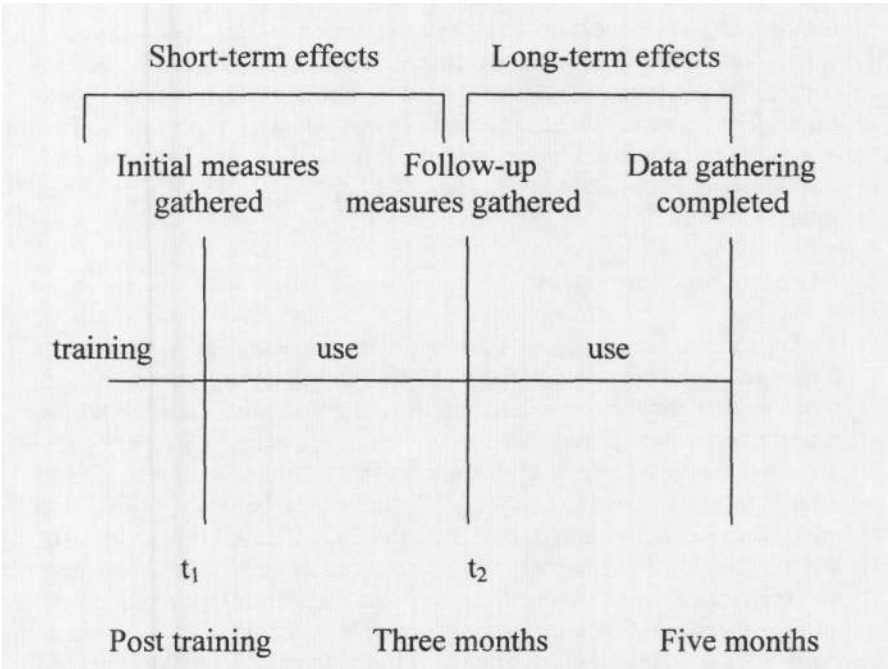

Figure 3: **Research Design and Timing of Measurement**

Results

Preliminary Analysis

The descriptive statistics and the intercorrelations among the key variables used in this research are presented in Table 1. A combination of factor analysis and reliability analysis was performed in order to evaluate the psychometric properties of the measures used in this study. The factor structure matrices based on principal components analysis with direct oblimin rotation and reliability analysis for t_1 and t_2 are presented in Tables 2a and 2b. The observed pattern of high reliability and validity was consistent with our expectations given that the scales have been extensively tested and validated in prior research (e.g., Mathieson, 1991; Taylor & Todd, 1995a).

Hypothesis Testing

Hierarchical regression was used to analyze the data. Hierarchical regression is an effective technique in this context as it allows us to keep

TABLE 1

Means and Intercorrelations of Key Variables

	Time 1		Intercorrelations					Time 2	
	M	*SD*	AGE	A	SN	PBC	USE	*M*	*SD*
AGE	38.2	9.1	1.00	−.25**	.16*	.30**	−.30**	38.2	9.1
A	4.8	.94	−.27***	1.00	.25**	.28**	.37***	4.8	.86
SN	4.7	.82	.25**	.24*	1.00	.20*	.15*	4.7	.92
PBC	4.6	.84	.27**	.20*	.28**	1.00	.36***	4.8	.88
USE	7.3	1.54	−.28*	.36***	.34***	.33***	1.00	7.2	1.61

Note: Time 1 intercorrelations are shown below the diagonal of this matrix and Time 2 intercorrelations are above the diagonal. A: Attitude Toward Using Technology; SN: Subjective Norm; PBC: Perceived Behavioral Control. Use reported above is a mean measure of frequency of system accesses in a week. Use reported in Time 1 refers to average weekly use measured from posttraining to Time 2. Use reported in Time 2 refers to average weekly use measured from Time 2 to 5 months post-implementation.

*$p < .05$ **$p < .01$ ***$p < .001$

TABLE 2a

Factor Structure Matrix at Time 1 (Direct Oblimin Rotation)

	1	2	3
A1	0.90	0.08	0.00
A2	0.88	0.10	0.09
A3	0.85	0.10	0.10
A4	0.95	0.14	0.10
SN1	0.11	0.88	0.14
SN2	0.10	0.88	0.12
PBC1	0.05	0.05	0.96
PBC2	0.02	0.11	0.92
PBC3	0.05	0.10	0.84
PBC4	0.08	0.10	0.86
PBC5	0.08	0.10	0.87
Cronbach α	0.90	0.87	0.85

TABLE 2b

Factor Structure Matrix at Time 2 (Direct Oblimin Rotation)

	1	2	3
A1	0.86	0.07	0.06
A2	0.84	0.08	0.08
A3	0.82	0.04	0.02
A4	0.90	0.10	0.11
SN1	0.08	0.91	0.13
SN2	0.09	0.90	0.10
PBC1	0.05	0.06	0.90
PBC2	0.04	0.02	0.95
PBC3	0.11	0.05	0.87
PBC4	0.13	0.11	0.82
PBC5	0.10	0.12	0.90
Cronbach α	0.89	0.90	0.90

Note: A1–A4: attitude toward using items; SN1–SN2: subjective norm items; PBC1–PBC5: perceived behavioral control items; USE is not included here due to objective nature of the measurement.

AGE in a continuous form, while also statistically evaluating the influence of potential confounds (e.g., occupational level, education level, etc.). For the primary dependent variable, USE, we entered both AGE and potential confounding variables in the initial step. In the second step, the TPB variables (A, SN, and PBC) were added to test the efficacy of TPB in this context and to help examine the potential mediation of AGE by the TPB constructs. In the third step, 2-way interaction terms including AGE, TPB constructs, and potential confounding variables (e.g., AGE × A, INCOME × A) were added. In the final step, 3-way interaction terms including AGE, TPB constructs, and potential confounding variables (e.g., AGE × A × INCOME) were entered. None of the direct or interaction effects of any of the three confounding variables were found to be significant. This suggested that the confounding

TABLE 3

Hierarchical Regression for Short-Term Usage

Step	IV	R^2	ΔR^2	β	p
1	AGE	.17	.17	−.40	***
2	AGE	.37	.20	−.09	
	A			.36	***
	SN			.24	**
	PBC			.25	**
3	AGE	.52	.15	.04	
	A			.17	*
	SN			.23	**
	PBC			.07	
	AGE × A			−.46	***
	AGE × SN			.41	***
	AGE × PBC			.39	***

Note: A: attitude toward using technology; SN: subjective norm; PBC: perceived behavioral control. An age-squared term was included but was not significant.
*$p < .05$ **$p < .01$ ***$p < .001$

variables did not play a role in influencing usage over and above age. Based on this analysis, it was decided to delete the confounding variables and re-analyze the data.

The results of the hierarchical regression models for both short-term usage (t_1) are presented in Table 3. As confirmed by Step 1, age does have an influence on short-term technology usage ($p < .001$; Hypothesis 1). Although not explicitly tested in the hierarchical regression model, AGE has an influence on A (−), SN (+), and PBC (+), as predicted by Hypothesis 2(a–c)—this is clearly discernible from the correlations (Table 1), as the effect of AGE on A, SN, and PBC is simply the correlation given the model in Figure 2. Based on Steps 2 and 3, it is evident that AGE moderates the effect of A, SN, and PBC on usage, with younger workers placing greater emphasis on A in determining use ($p < .001$; Hypothesis 3a), older workers weighting SN and PBC more strongly ($p < .001$) in determining use than younger workers did at t_1 (Hypothesis 3b and 3c). Finally, given the effects of AGE on A, SN, and PBC, and the fact that AGE has no direct effect on usage over and above A, SN, and PBC (step 2), the effect of AGE can be said to be fully mediated by TPB constructs, thus supporting Hypothesis 4.

Over the long term, the pattern of results (Table 4) was as expected (Hypotheses 5 through 8) and largely consistent with the short-term results. The only exception was that in the long-term subjective norm was nonsignificant as a determinant of usage, both as a direct effect and an interaction term, which was consistent with expectations.

TABLE 4
Hierarchical Regression for Long-Term Usage

Step	IV	R^2	ΔR^2	β	p
1	AGE	.14	.14	−.38	***
2	AGE	.32	.18	−.13	
	A			−.40	***
	SN			.04	
	PBC			.27	***
3	AGE	.48	.16	−.08	
	A			.20	*
	SN			.05	
	PBC			.16	
	AGE × A			−.43	***
	AGE × SN			.08	
	AGE × PBC			.46	***

Note: A: attitude toward using technology; SN: subjective norm; PBC: perceived behavioral control. An age-squared term was included but was not significant.
*$p < .05$ **$p < .01$ ***$p < .001$

Discussion

The results suggest that there are clear differences with age in the importance of various factors in technology adoption and usage in the workplace. As hypothesized, initial acceptance decisions of younger workers found attitude toward using a new technology to be more salient than older workers; conversely, older workers weighed the importance of subjective norm and perceived behavioral control more strongly than younger workers in determining usage of a new technology in the short term. For long-term usage decisions, the pattern of results for attitude toward using technology and perceived behavioral control was consistent with the initial adoption decision; however, there were no differences in subjective norm. These results were present even after controlling for potential confounding variables (income, occupation, and education). In addition, an age-squared term was added to our preliminary analysis to examine whether age-related changes might be asymptotic; however, the term was nonsignificant, suggesting that the influence of age is linear for this sample. Therefore, it appears that age does have important influences on technology adoption and sustained usage decisions.

Given our results, a clear theme emerges. Specifically, in the short term, most factors outlined by TPB are significant for both younger and older workers; however, the salience of each factor varies with age. Specifically, younger workers appear to be more driven by underlying attitudinal factors whereas older workers are more motivated by social and process factors. Over the long term, the contrasts were equally striking. After 3 months of experience with the system, older workers no longer

placed significant emphasis on subjective norm; that is, they were no different than younger workers in this regard. Given current theoretical perspectives, this was not surprising—as noted earlier, we only expected subjective norm to have an influence on older workers' *initial* decision to use technology and that subjective norm would become nonsignificant with increasing experience (i.e., during measurement after 3 months of use) due to internalization of normative influences. The data suggests that the internalization process occurs quickly. In fact, in this case, 3 months was long enough for internalization to take place, rendering subjective norm nonsignificant for both groups at that point. Given that these results were robust to potential confounds, the modified TPB framework incorporating age, proposed in this paper, appears sound.

In the light of these consistent findings, it is interesting to speculate about the underlying causal mechanisms for these striking differences in technology adoption decisions across age groups. That is, *why* might attitude toward using the technology be more important for younger workers whereas subjective norm and perceived behavioral control are more important for older workers? One possible explanation is that those in their twenties and thirties (i.e., relatively "younger" workers in this study) are much more likely to have been exposed to information technology at a relatively early age—perhaps as early as elementary school in some cases. This is much less likely for older employees because they would have completed high school (and in many cases, college) before the personal computer was commonplace. In other words, the opportunity for older workers to interact with information technology before entering the workplace was much more limited. Thus, it is reasonable to assume that older workers may be much more accustomed to seeking and applying traditional (i.e., "nontechnology") solutions to job-related tasks whereas younger workers are much more reliant on the use of technology for job accomplishment. This might explain why productivity-oriented factors (i.e., the degree to which the technology helps them perform their job better) are more salient for younger workers. The finding that subjective norm is more salient for older workers (at least in the short term) may also simply reflect a greater comfort level with technology on the part of younger workers. Having grown up in the age of the personal computer, younger workers may simply have more experience making independent judgments about technology and may not care as much about what those around them believe. On the other hand, older workers may be less confident in their ability to render independent judgments about various facets of new technology and may be more likely to seek out and consider the opinions of those offered by friends and coworkers. Similarly, older workers in this sample also appear to rely more heavily on those sources of support that are most

likely to be consistent with the training they received about new information technology. With regard to perceived behavioral control, they appear to weigh issues of ease or difficulty of using the new technology more heavily than younger workers do—a finding that is consistent with differences one might expect between a group trained on technology in a workplace setting versus those exposed to technology at a younger age in a classroom-oriented environment.

The discussion above is consistent with a cohort explanation of the differences seen in this sample. In other words, the past experiences (i.e., exposure, training, and use of information technology) of the younger cohort in this sample were different from the past experiences for the older group. If this explanation were true, as the younger cohort matures, we would expect little change in the importance they place on each of the factors examined in this research. An alternative explanation is that aging and the associated psychological and sociological processes in and of themselves are the driving factor behind the differences observed (e.g., Rhodes, 1983). Thus, one might explain the observed differences in terms of biological aging effects, including changes in the human perceptual and sensorimotor systems. For example, we know that perception is a complex psychological process and that aging reduces the speed and amplitude of perception (e.g., Minton & Schneider, 1980). Similarly, the loss of visual and auditory acuity together can create problems for reading or for signal detection (Forteza & Prieto, 1990). Modern information technology often relies heavily on subtle cues to present information (e.g., "grayed out" menus to indicate those functions are not available at a given time). Older workers may have a difficult time perceiving these cues, rendering cues about how to use the system less effective, and making the system very difficult to use. Thus, given the close linkage between perceived behavioral control and system ease of use, it is not difficult to see how biological aging can have important influences on user perceptions of the system such as perceived behavioral control. Similarly, one might examine changes in need structures, expectations, and progression through work and nonwork roles as alternative explanations to the cohort phenomenon discussed above. For example, workers are often more concerned with promotion opportunities and income early in their careers, although later in their working lives, they shift their focus to security and pleasant social relations (Wright & Hamilton, 1978). This might explain the importance of attitudes (driven by instrumentality) for younger workers and the increased salience of social factors (SN) for older workers when looking at the initial technology adoption decision.

Obviously, the underlying cause for such differences can never be stated with certainty in most studies of this nature. Resolving the issue

of whether age differences are due to cohort effects or the aging process itself can never be completely known until future studies are done that look at individuals born in the post-baby boom era (i.e., the relatively "younger" subjects in this study) as they begin to reach the age of 40 and beyond. Thus, although both cohort and age effect explanations have an intuitive appeal, only carefully structured longitudinal research can establish whether one—or both—of these explanations is valid.

An interesting third possibility in this or any other study of chronological age, is the notion that age may serve as a surrogate for other organizational phenomena. For example, age differences may also reflect work experiences an individual has accumulated over time (e.g., previous technology training) that may have some influence on individual use of new technology beyond those effects directly associated with the aging process. In fact, Sterns and Doverspike (1989) illuminate various interpretations of the context in which age differences must be considered. Their analysis highlights additional theoretical perspectives on the age construct that may be addressed in the context of technology adoption in subsequent work in the domain (e.g., psycho-social perspectives, organizational/job tenure, and life span orientations).

Regardless of the theoretical explanation for the underlying reason for the observed differences, these results carry important practical implications for today's workforce. For example, given the differences between older and younger workers, training programs should be structured with the needs of both groups taken into account. For example, the most important factor to younger workers is related to instrumentality. Thus, when implementing new technology, trainers and managers may wish to emphasize how the new technology will assist workers in increasing productivity or achieving more effective results. On the other hand, older workers appear to be more influenced by perceived behavioral control. Here, trainers may wish to emphasize new technology's ease of use in order to get "buy-in" from older workers who may be inherently skeptical about applying new technology in the workplace. Given the importance of social factors for older workers, especially in the crucial initial stages of adoption, it may be important for managers to cultivate positive reactions about the new technology from opinion leaders within the organization. In so doing, managers may find that these leaders may be a tremendous help in shaping "public opinion" about the new system, thus increasing the likelihood of widespread acceptance across the organization, particularly among workers with significant longevity. Training processes themselves should also be examined for modification. For example, older workers see themselves as unsuited to new learning and lack confidence in training situations (e.g., Plett & Lester, 1991). Older workers also tend to learn at a slower pace than their younger colleagues

(Sterns & Doverspike, 1989). Specifically with respect to information technology, older employees are less likely to have a basic knowledge of terminology and basic computer equipment, further raising their anxiety about technology and training in general. Therefore, it may be useful for technology trainers to provide opportunities for "technology familiarization" prior to teaching the specific details of an advanced database or production control system in the organizational environment (for example). Research also shows that older workers are often "out of practice" in understanding how to learn (see Warr, 1990, for a review); thus, older workers can have a particularly difficult time absorbing new material or demonstrating competence at new tasks. This initial familiarization can not only help older workers become comfortable with the learning process and classroom environment itself, it can also help to reduce anxiety about technology and create a more positive attitude toward using the technology—an obvious area of concern based on the results of this study. Similarly, it may be helpful for organizations to provide greater learning opportunities for employees throughout their tenure in order to provide support for continuous learning. As organizations begin to emphasize and reward continuous learning earlier in the life span, it is possible that the anxiety of using new technologies later in the life span may eventually disappear.

Implicit in this discussion is the need to understand the specific decision-making processes of the primary users for a new technology. Rarely is technology implemented uniformly across all groups within an organization; rather, technology is likely to affect various groups of workers (i.e., demographic groups, functional groups, etc.) differently. Thus, analysts and managers involved in the development process for the new technology should conduct a thorough user analysis in order to better understand which groups are most likely to be affected by the technology. Then, those groups may be brought into the development process early on and developers can focus their efforts around those factors that are likely to be "hot buttons" for that set of users, thereby preempting concerns or problems with that new technology from its primary user base. In the end, our results suggest that management strategies for technology adoption and implementation that treat "the work force" as a monolithic entity and fail to appreciate the very real differences across age groups are themselves likely to fail.

Limitations and Additional Future Research Directions

One potential limitation of this study involves the measurement and analysis of the primary construct of interest—age. As noted earlier, in this research, we used "chronological age" as the basis to understand

age differences. However, other conceptualizations of the age construct have been offered in the literature including "psychological age" (defined as the ability of one to relate successfully to his or her environment or changes therein) or "social age" (defined as the examination one's roles and behavior and the degree to which those behaviors are consistent with the expectations for the individual's chronological age group; Minton & Schneider, 1980). It is possible that each of these constructs affects one's view of technology adoption differently, and further research in this area might serve to further our understanding of the underlying causal mechanisms related to age-based differences in technology adoption and usage. Similarly, given the exploratory nature of this work, the use of different points of measurement as a proxy for experience was considered appropriate. However, future work should refine that measure to reflect the actual amount and quality of experience with the system.

With regard to the confounding variables measured, we were unable to measure gender in this research because of restrictions imposed by the participating organization. However, we have studied gender differences in technology adoption and usage in related research (see Venkatesh & Morris, in press; Venkatesh et al., in press). In that research, we were unable to publish results related to age differences, yet again due to restrictions imposed by the participating organizations. It behooves researchers to understand age and gender differences within the context of a single research study.

Although one of the strengths of the current work is the longitudinal field investigation, the study was limited to one organization with a relatively small sample size. Additional research is essential to examine the generalizability of these findings to other organizational settings and technologies. A related issue that merits note from a statistical point of view is the result for subjective norm over the long term. We hypothesized that social influences would be attenuated over the long term as the underlying causal mechanisms shift from "compliance" to "internalization" (Venkatesh & Davis, in press; Warshaw, 1980). As we have noted, the potential for Type II error is a concern, and the results must be interpreted cautiously; however, this pattern of nonsignificant subjective norm with increasing experience with the system is consistent with other recent research on technology adoption (Venkatesh & Davis, in press; Venkatesh & Morris, in press; Venkatesh, Morris, & Ackerman, in press, who found a similar pattern across four separate studies). Future research might target a larger sample as a means of increasing statistical power to more conclusively establish subjective norm as a nonsignificant determinant in the long term. Similarly, collecting data across multiple

organizations would help establish the generalizability of this research to other organizational contexts.

Additional research also might be usefully directed at the issue of training strategies for technology introduction for older workers. The earlier discussion noted that older workers may benefit from introductory familiarization training prior to specific application-centric training. Future research might test this in a laboratory or field environment. In addition, field research on technology adoption in organizations that actively promote continuous learning throughout the life span could be compared with those with more restrictive philosophies toward continuous learning to see whether organizational philosophy and culture with respect to training can overcome some of the barriers to technology adoption for older workers presented in this research. Similarly, the issue of organizational culture in general offers a complex, but potentially interesting line of future research. For example, examining the norms for treatment of older workers in the company may provide valuable insights into causal factors for the age differences shown here. More specifically, understanding cultural norms with respect to technology implementation might provide valuable insights into hurdles faced by older workers in using new technology (e.g., do older workers get the worst technology when allocation decisions are made?).

Conclusions

"Baby boomers," "Gen Xers," the "me generation,"—our society is fond of labeling different age groups as if to suggest that each group is quite different from the others. Although this debate is beyond the scope of the current research, the current work suggests that for technology adoption decisions, age, in fact, matters. Given increases in the expected working life of individuals, this finding has important implications for the process by which technology is developed, introduced, and managed within organizations. The current work points out that understanding specifically who the user is can have an important influence on a given technology's acceptability to that user. Only by understanding the underlying drivers of individual technology acceptance and usage decisions can organizations effectively deliver appropriate support mechanisms designed to help the user perform his or her job. This research offers an important first step in understanding how the aging process influences technology adoption decisions in today's changing workforce.

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APPENDIX

Age: ____ years

Annual individual income (before taxes):
- ◯ Less than $20,000
- ◯ $20,000–$29,999
- ◯ $30,000–$39,999
- ◯ $40,000–$49,999
- ◯ $50,000–$59,999
- ◯ $60,000–$69,999
- ◯ $70,000–$79,999
- ◯ $80,000 - $89,999
- ◯ $90,000–$99,999
- ◯ $100,000 or more

Position:
- ◯ Executive/top management
- ◯ Middle management
- ◯ Supervisory
- ◯ Administrative/clerical
- ◯ Technical
- ◯ Other: _____ (please specify)

Education level:
- ◯ Some high school or less
- ◯ Graduated high school
- ◯ Vocational/technical school
- ◯ Some college
- ◯ Graduated college
- ◯ Post-graduate study

Intention to use (7-point Likert scale)

Assuming I had access to the system, I intend to use it.
Given that I had access to the system, I predict that I would use it.

Attitude toward using (7-point semantic differential scale)

Using the system is a (bad/good) idea.
Using the system is a (foolish/wise) idea.
I (dislike/like) the idea of using the system.
Using the system is (unpleasant/pleasant).

Subjective norm (7-point Likert scale)

People who influence my behavior think that I should use the system.
People who are important to me think that I should use the system.

Perceived behavioral control (7-point Likert scale)

I have control over using the system.
I have the resources necessary to use the system.
I have the knowledge necessary to use the system.
Given the resources, opportunities and knowledge it takes to use the system, it would be easy for me to use the system.
The system is not compatible with other systems I use.